Sorbent Injection for Small ESP Mercury Control in Low Sulfur Eastern Bituminous Coal Flue Gas

Quarterly Technical Progress Report July 1 – September 30, 2004

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Abstract

This document summarizes progress on Cooperative Agreement DE-FC26-03NT41987, "Sorbent Injection for Small ESP Mercury Control in Low Sulfur Eastern Bituminous Coal Flue Gas," during the time-period July 1, 2004 through September 30, 2004. The objective of this project is to demonstrate the ability of various activated carbon sorbents to remove mercury from coal-combustion flue gas across full-scale units configured with small ESPs. The project is funded by the U.S. DOE National Energy Technology Laboratory under this Cooperative Agreement. EPRI, Southern Company, and Georgia Power are project co-funders. URS Group is the prime contractor.

Various carbon-based sorbents were injected upstream of low SCA ESP systems at Georgia Power's Plant Yates Unit 1 and Unit 2. Both Unit 1 and Unit 2 fire a low sulfur bituminous coal. Unit 1 is equipped with a JBR wet FGD system downstream of the ESP for SO₂ control. Unit 2 is not equipped with downstream SO₂ controls; however, a dual flue gas conditioning system is used to enhance ESP performance.

Short-term parametric tests were conducted on Units 1 and 2 to evaluate the performance of activated carbon sorbents. In addition, the effects of the dual flue gas conditioning system on mercury removal performance were evaluated as part of the short-term parametric test on Unit 2. Based on the results of the parametric tests, a single sorbent has been selected for longer term full-scale tests on Unit 1 to observe long term performance of the sorbent, and its effects on ESP and JBR FGD system operations and combustion byproduct properties. The results of this study will provide data required for assessing the performance, long-term operational impacts, and estimating the costs of full-scale sorbent injection processes for flue gas mercury removal.

This is the fourth full reporting period for the subject Cooperative Agreement. Work during this period focused on planning for the long-term sorbent injection tests.

Table of Contents

1.0	Exec	cutive Summary	1-1
2.0	Experimental		2-1
	2.1	Plant Configuration	2-1
	2.2	Experimental Methods	2-1
	2.3	Progress by Task	
3.0		ılts and Discussion	
4.0	Conc	clusions	4-1
5.0	Activ	vities Scheduled for Next Quarter	5-1
6.0	Refe	rences	6-1

List of Figures

2-1	Unit 1 Configuration and Flue Gas Sample Locations	2-4
2-2	1	
2-3	Reduction in Vapor Phase Mercury Concentration at ESP Outlet for the	
	Three Sorbents Tested in the Unit 1 Parametric Tests	2-6

List of Tables

2-1	Plant Yates Unit 1 and 2 Configurations	2-1
	Schedule for FY 2004 Milestones for this Test Program	
	Sorbents Selected for Test Program	

List of Acronyms

acfm Actual cubic feet per minute
ACI Activated Carbon Injection
APCD Air pollution control device

APH Air preheater

ASTM American Society for Testing and Materials

CEM Continuous emissions monitor

CO₂ Carbon dioxide

CT-121 Chyodia Thoroughbred - 121 CVAA Cold vapor atomic absorption

ΔP "Delta P", Pressure drop or pressure difference

DOE Department of Energy

EPA Environmental Protection Agency EPRI Electric Power Research Institute

ESP Electrostatic precipitator FGD Flue gas desulfurization

FGDTM Norit America's Darco FGDTM activated carbon

HCl Hydrochloric acid

Hg Mercury

HOK RWE Rhinebraun's Super HOK activated carbon

IGS Inertial gas separation
JBR Jet bubbling reactor
LOI Loss on ignition

MW Megawatt

NETL National Energy Technology Laboratory

NH Carbon Ningxia Huahui Activated Carbon

NH₃ Ammonia

NIST National Institute of Standards and Technology

NO Nitrogen oxide
NO₂ Nitrogen dioxide
NO_X Nitrogen oxides
OH Ontario Hydro

PSD Particle size distribution

QA/QC Quality assurance/quality control

SCA Specific collection area

SCEM Semi Continuous Emission Monitor

SO₂ Sulfur dioxide SO₃ Sulfur trioxide U.S. United States

1.0 Executive Summary

This document summarizes progress on Cooperative Agreement DE-FC26-03NT41987, "Sorbent Injection for Small ESP Mercury Control in Low Sulfur Eastern Bituminous Coal Flue Gas," during the time-period July 1, 2004 through September 30, 2004. The objective of this project is to demonstrate the ability of various activated carbon sorbents to remove mercury from coal-combustion flue gas across full-scale units configured with small ESPs. The project is funded by the U.S. DOE National Energy Technology Laboratory under this Cooperative Agreement. EPRI, Southern Company, and Georgia Power are project co-funders. URS Group is the prime contractor.

Several carbon-based sorbent materials were injected upstream of low SCA ESP systems at Georgia Power's Plant Yates Unit 1 and Unit 2. Both Unit 1 and Unit 2 fire a low sulfur bituminous coal. Unit 1 is equipped with a cold-side ESP upstream of a JBR wet FGD system for SO₂ control. Unit 2 is not equipped with downstream SO₂ controls; however, a dual flue gas conditioning system is used to enhance ESP performance.

The primary activity during this fourth quarter of the test program was planning for the long-term sorbent injection tests.

Planning for Long-term Injection Testing

The long-term test will start in the middle of November 2004 and will conclude in the middle of December 2004, after 30 days of continuous sorbent injection testing. RWE Rheinbraun's Super HOK sorbent was selected for the long-term injection tests on Yates Unit 1. The Super HOK sorbent has been ordered from the manufacturer, which is located in Germany. The sorbent is currently en route to the United States. The silo for the sorbent has been installed at Plant Yates.

2.0 Experimental

2.1 Plant Configuration

Figures 2-1 and 2-2 show the basic plant configuration, sorbent injection points, and flue gas sample locations for Units 1 and 2, respectively. Characteristics of each unit are summarized in Table 2-1 and have been described in previous reports.

Table 2-1. Plant Yates Unit 1 and 2 Configurations

	Yates Unit 1	Yates Unit 2		
Boiler				
Type	CE Tangential Fired			
Nameplate (MW)	100			
Coal				
Type	Eastern B	Eastern Bituminous		
Sulfur (wt %, dry)	1.0			
Mercury (mg/kg, dry)	ercury (mg/kg, dry) 0.06-0.14			
Chloride (mg/kg, dry)	150-450			
ESP				
Type	Type Cold-Side			
ESP Manufacturer	Buell (1968 and 1971 vintage, refurbished in 1997)			
Specific Collection Area	173	144		
$(ft^2/1000afcm)$				
Plate Spacing (in.)	1	1		
Plate Height (ft)	3	30		
Electrical Fields	3	2		
Mechanical Fields	4	3		
ESP Inlet Temp. (°F)	310	300		
ESP Design Flow Rate (ACFM)	490,000	420,000		
NO _x Controls	Low NOx Burners	None		
SO ₂ Controls	Chiyoda CT-121 wet	None		
	scrubber (JBR)			
Flue Gas Conditioning	None	Dual NH ₃ /SO ₃		

2.2 Experimental Methods

The sorbent injection equipment was described in the first technical report. The mercury measurements for baseline and injection testing were performed with mercury semi-continuous analyzers, which have been described in previous reports. Particulate loading was measured via Method 17 at one point in the duct. During baseline testing, Ontario Hydro, Method 26a measurements for halogens, and particulate loading via Method 5 were conducted.

Solid and liquid samples, such as makeup water, fly ash, and coal, were collected and analyzed for mercury content. Fly ash and coal mercury were digested with ASTM 3684 and

analyzed for mercury by CVAA. The coal was digested by ASTM 4208 and analyzed for chloride by Method 300.

2.3 Progress by Task

Progress on the various project tasks are described in the following sections. A summary of progress is provided in Table 2-2.

Table 2-2. Schedule for FY 2004 Milestones for this Test Program

		Planned	Actual
Milestone	Description	Completion	Completion
1	Hazardous substance plan	Q1	Q1
2	Project kickoff meeting	Q1	Q1
3	Site Survey – Units 1 and 2	Q1	Q1
5	Test plan – Units 1 and 2	Q1	Q2
6	Complete sorbent injection system installation for parametric tests – Units 1 and 2	Q2	Q2
7	Complete baseline and parametric tests for sorbent 1 (Darco FGD TM carbon) on Units 1 and 2	Q2	Q2
8	Complete baseline and parametric tests for sorbent 2 (Super HOK carbon) on Unit 1	Q3	Q3
9	Transfer and install ACI silo and feeder system on Unit 1 for long-term tests	Q4	Q4
10	Initiate long-term test on Unit 1	Q4	
11	Complete long-term test on Unit 1	Q4	
12	Complete data workup for Units 1 and 2	Q2-FY2005	
13	Initiate economic analysis	Q2-FY2005	

Task 1 – Project Planning

Three different sorbents were evaluated in the parametric tests on Unit 1. A description of each sorbent is provided in the Table 2-3. RWE Rheinbraun's Super HOK sorbent was selected for the long-term tests on Unit 1. The sorbent was selected because of its comparable performance and lower cost compared to Norit America's Darco FGDTM. Figure 2-3 shows the performance curves for three tested carbons. The percent reduction in vapor phase mercury concentration at the ESP outlet is plotted against the sorbent injection rate. For the Darco FGDTM and the Super HOK, mercury reduction reached a plateau of 35-45% at an injection rate between 6 and 9 lb/Mmacf. It is anticipated that an injection rate between 6 and 9 lb/Mmacf will be needed to control ESP outlet mercury concentration to below 2 lb/trillion Btu.

An order was placed for 88,000 lb of sorbent. The sorbent is being shipped in two batches from Germany. Transport is by boat to Savannah, GA. The first batch left Germany on

September 24, 2004 and the second batch left on October 1, 2004. The sorbent will be shipped by vacuum truck from Savannah to Plant Yates.

The sorbent will be stored and fed from a silo that can accommodate up to 40,000 lb of sorbent. The silo was installed at Plant Yates during this past quarter. The feed mechanism will be calibrated during the next quarter, just prior to commencement of the long-term injection test.

Carbon Name Manufacturer Cost (\$/lb) **Description** Lignite-derived activated carbon; baseline 0.50 Darco FGDTM Norit Americas carbon (19 µm mean particle size) German lignite-derived activated carbon (23 0.38^{a} Super HOK RWE Rhinebraun um mean particle size) 0.88 Ningxia Huahui Chinese iodated bituminous-derived activated NH Carbon Activated Carbon Co. carbon (24 µm mean particle size) LTD (HHAC)

Table 2-3. Sorbents Selected for Test Program

Task 2 - Unit 1 Testing

The Unit 1 parametric testing with Darco FGDTM, Super HOK, and NH carbons has been completed and results have been reported in previous quarterly reports. A long-term performance test is planned to begin in mid-November 2004. The initial plan had been to perform the long-term test during FY04-Q4. However, several factors resulted in a delay in the initial schedule; these factors were associated with plant operation during ozone attainment season and a Unit 1 outage during October. It was thus determined that the best time to perform the long-term test was November-December, 2004.

Task 3 – Unit 2 Testing

The Unit 2 parametric testing with Darco FGDTM carbon has been completed and results have been reported in previous quarterly reports.

Task 4 – Data and Economic Analysis

Data analysis of the parametric tests on Units 1 and 2 has been completed and is reported in previous quarterlies. No activity was conducted related to the economic analysis.

Task 5 – Waste Characterization

No samples for waste characterization were taken during the current reporting period.

a = F.O.B. Pennsylvania

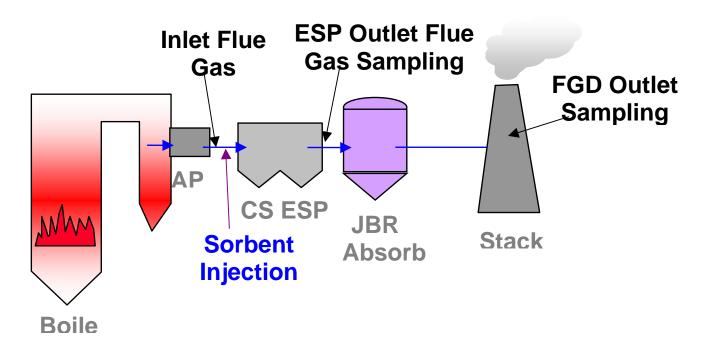


Figure 2-1. Unit 1 Configuration and Flue Gas Sample Locations

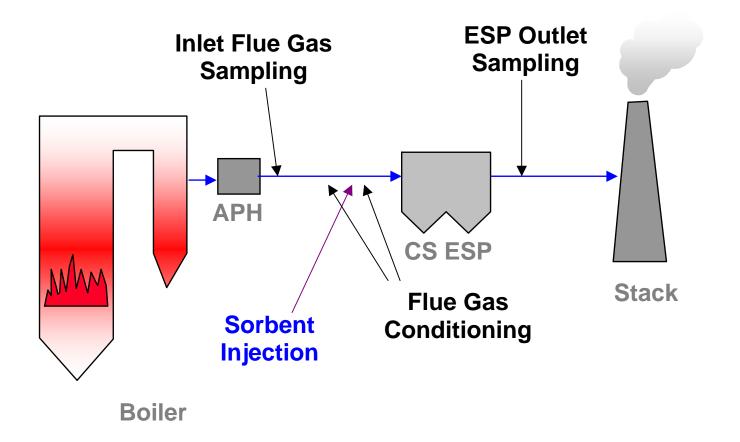


Figure 2-2. Unit 2 Configuration and Flue Gas Sample Locations

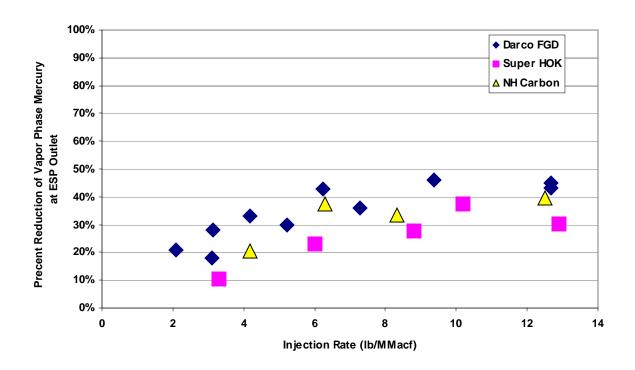


Figure 2-3. Reduction in Vapor Phase Mercury Concentration at ESP Outlet for the Three Sorbents Tested in the Unit 1 Parametric Tests

3.0 Results and Discussion

Data from the parametric tests on Units 1 and 2 were reduced, analyzed, and reported in previous quarterly reports. These reports analyzed the mercury reductions achieved with activated carbon injection. Results were analyzed in terms of other process data, such as boiler load, temperature, and ESP performance.

4.0 Conclusions

Parametric testing on Units 1 and 2 has been completed and results have been reported in previous quarterly reports. During this quarter, the primary activity was planning for the long-term injection test. RWE Rheinbraun's HOK sorbent was selected for the long-term testing based on its performance and cost. Sorbent has been ordered and is in transport to the United States. The sorbent silo has been installed. Long-term testing begins in the middle of November 2004.

5.0 Activities Scheduled for Next Quarter

The next quarterly reporting period covers the period October 1, 2004 through December 31, 2004. The primary activities planned for this period include execution of the long-term sorbent injection test and initial data reduction activities. Long-term test activities will include evaluation of sorbent performance over 30 days of continuous injection as well as any effects on ESP or scrubber performance. Ontario Hydro gas characterization tests will be made to verify the results obtained with mercury analyzers. Byproduct samples will be collected from both the ESP and FGD unit for future evaluation by NETL.

6.0 References

None for this document.